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ABSTRACT

The new economic and industrial policies of the 1980s called for a major restructuring of the industrial profile of Singapore. The government decided to set up three new technical institutes to prepare and supply skilled workers to new investors: French-, German-, and Japan-Singapore Technical Institutes with the collaboration of the government and industries in the respective countries. The technology to be transferred was that of running technical training institutes. The Japan-Singapore Technical Institute (JSTI) was created to provide skilled workers for operation and maintenance jobs. A few critical characteristics of the institutional arrangements were institutional training; educated, experienced staff; and freedom to organize training around workplace needs. Other characteristics of the Japanese style emerged: total immersion in the work and managerial style. Five years after its start, JSTI realized the need for more technical education and less skills training. The addition of a mechatronics course reflected the distinctive characteristics of the institution and the Japanese influence during the development phase. Results included the following: most students received scholarships and were bonded for 3 years after graduation; curriculum changes included offering a higher order certificate and moving into research and development activities; and JSTI was not only a training institute, but also helped promote and sustain Singapore's technological development. (YLB)

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# TRAINING discussion PAPERS

## The technology of technology transfer

by João Batista Araujo e Oliveira
and Gerald F. Pillay

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Discussion Paper No. 93

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# The case of the Japan-Singapore Technical Institute

by João Batista Araujo e Oliveira and Gerald F. Pillay

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# Preface

*This paper was prepared in the context of an ILO study of the impact of new work technologies on training. It describes and analyses a successful case of technology transfer between Japan and Singapore. In this case, the adaptation of institutions to train technical workers to meet the increasingly sophisticated demands of the Singaporean economy.*

*The study was based on a number of personal interviews by the authors in Singapore during 1991. The interviews included government officials, those responsible for the training institutions mentioned as well as with a number of managers and technical workers in local firms. The authors would like to take this opportunity to thank all of them for their precious time and ideas.*

*The findings of this case study are reproduced in this series of discussion papers because they are likely to be of interest to policy-makers and training managers in other countries. This is particularly the case of those industrialized countries which are currently attempting to modernize and upgrade their production technologies and to make their training systems more responsible to the changing needs of their local industries.*

# Contents


**Preface** iii

**I. Introduction** 1

**II. Background** 3

**III. Using past experience** 5

A. The JSTI - the first five years 6

B. The second phase 7

C. Some thoughts about the second phase 11

**IV. Results and perspectives** 13

A. Students 13

B. Curriculum 13

C. Faculty 13

D. Institute-industry integration 13

E. EDB 14

# I. Introduction

This is a case study about a certain type of technology transfer: the technology of running technical training institutes. But since these institutes deal with high tech training, the case is also about the cross-cultural transfer of work technologies involved in modern manufacturing. High tech is an abbreviated way to refer to new ways of production based on automation or electronics.

The word technology, here, will be used in different ways, including its hard and soft meanings: new production technological machines and tools; technology of organising for production; technology of setting up training institutes; the technology of learning how to manage transfer of technology.

When we refer to technology, we will be dealing with three common denominators: (1) thinking a problem through; (2) distilling comparable experiences; and (3) creating your own solutions. Successful technology transfer can only occur when these three aspects have been duly taken into account. Following this concept, the emphasis of the present case study will be on how Singapore acquired the competence (technology) to operate high tech technical institutes, based on a technical co-operation agreement with Japan.

In the world of technical education and vocational training, many examples exist of foreign co-operation to help set up training institutions. More often than not, the typical pattern is that of a donor, generally a developed country, setting up a technical institution modelled after that of the donor country. Most of the resources are spent on buildings, equipment acquisition and foreign experts to help start the operations and to train the trainers and managers of the new institution. In some cases, this process is undertaken with the assistance of intermediate organisations, such as bilateral donors or multilateral agencies, such as the ILO (International Labour Office). Such organisations may help in a number of ways: to define the problem; to identify potential sources of financing or technical assistance; to buy equipment on behalf of the recipient country; to organise training; to select and deploy consultants; to oversee the implementation of the project.

Institution-building efforts of this nature work better in some countries than in others. The successful cases are the ones in which the recipient country acquires the competence to reproduce the whole cycle of project implementation by itself, at a comparable level of competence and performance. A less successful implementation occurs when the recipient country can at least run the institutions on its own, after the foreign experts are gone. This may require some adaptations to local circumstances - since projects very often tend to create exceptions that are impossible to maintain in the long run.

In many cases, however, a typical pattern is one of progressive deterioration of the institution, the equipment received and of the human resources. Deterioration can either be caused by abandoning the institution to itself but cutting its privileges - since it is so different from the mainstream, or by attempting to incorporate it under the common bureaucratic rule - thus killing its unique features. In both cases the recipient country fails to learn from the process and to incorporate the potential innovations brought about by the new training institution. Very often some poor, recipient countries are left with a wide diversity of decaying vocational training models, each imprinted by a different donor country, but retaining only a pale image of the original distinctiveness.

In recent years, such patterns have started to be reversed, as countries become more active in the process of technology transfer and technical co-operation. Recipient countries are playing a more important role in defining their own needs; in negotiating the conditions of the technical assistance; in defining and selecting the types of experts they need; in clearly defining the tasks of the various experts; in promoting and programming the phasing out of the foreign assistance.

The history of the technological centres implemented by SENAI (Serviço Nacional de Aprendizagem Industrial) in Brazil is a good example. Several such centres have been created in various parts of Brazil, each one under a specific contractual agreement with a foreign institution selected by SENAI in a developed country. These new centres have two major functions: to transfer advanced sector-specific production technology to local industries and to train skilled workers and technicians in the use of this advanced technology. Over a space of ten years, more than 12 such institutions were created. All technical assistance contracts were centrally negotiated by the same unit, and in some cases, by the same staff. As a result, SENAI has developed a capacity to maximise the quality and relevance of foreign assistance, reduce its costs and the time to negotiate and implement new centres (Oliveira, 1992).

Singapore offers an even more sophisticated and complex model of using foreign assistance to implement high tech technical institutes. The history, development and results of this process is described in this case.

# II. Background

The late seventies marked a turning point for the Singaporean economy. The model of cheap, low cost labour-intensive technologies was exhausted, due to internal and external reasons: the supply of labour was limited by demographic growth; the high tech firms the country wanted to attract would need a fairly high number of highly qualified workers; it was not to a small country's advantage to continue to supply cheap labour in a world of increasing technological change.

Singapore's economic success depended upon its entrepreneurship and expertise - in commerce, finance, professional services and manufacturing. Since expertise could only be acquired through knowledge, practice and constructive experience, one of the keystones of Singapore economic policy is to relentlessly educate and train its manpower, at all levels, to the best of their abilities. The Economic Development Board (see box below) plays a major role to achieve these goals.

**The Economic Development Board**

EDB, a statutory board set up in 1961, is responsible for planning, developing, co-ordinating and promoting investment in manufacturing and related service industries. Since 1986, in partnership with Government agencies, it also promotes the services sector, and the development of local small and medium enterprises... It assists investors to obtain land and factory space, long-term financing, skilled manpower and other services.

Singapore- Facts and Pictures 1990. Singapore: Ministry of Communications and Information, 1990. p. 39.

The new economic and industrial policies of the eighties called for a major restructuring of the industrial profile: Singapore was to become an attractive place for high-tech industries and services. Among the various policies and infrastructures put in place, education and training received high priority. No longer was the country to offer only a cheap, tame, disciplined, English-speaking work force. Singapore was to increase the income level of its labour force and to upgrade the general level of education and training as an integral part of its package to be offered to prospective investors.

Among the several reforms in the education and training systems, the government decided, in the early eighties, to set up three new technical institutes to prepare and supply skilled manpower to new investors. For this reason, the new institutions were placed under the responsibility of EDB.

The major purposes of these technical institutes were fourfold: to train human resources with technical capabilities required to attract high-tech industries; to train human resources with attractive profiles for major investors; to provide an outlet for the country to learn about new work processes and technologies; to help bridge the gap between training institutions and the firms; and, finally, to ensure a supply of highly technically trained people for the key sectors of the economy. Priority areas for these institutions were also defined: automation, electronics and new production technologies.

EDB then moved on to establish criteria for the choice of the countries which would provide the inspiration and models for these new institutes. Rather than passively receiving technical co-operation, or asking external agencies to identify such countries for them, EDB set up four criteria for identifying and selecting prospective partners. First, these countries should be in the forefront of production technology in the priority areas mentioned above. Second, the selected countries should be heavily involved or likely to be heavily involved in Singapore. Third, these countries should be more likely to install modern factories requiring highly skilled manpower - and not simply labour-intensive operations. And finally, EDB would select countries interested in partnership, instead of working directly with individual training institutions. The reasons for the latter criterion lies in the mission set up for the new institutions, and which was not limited to training, but to be an integral part of EDB's mission and strategy.

On the basis of the purposes, priorities and criteria set up by the EDB, and after extensive fact finding and negotiations three agreements were signed in 1982/1983 to set up the French-, the German- and the Japan-Singapore Technical Institutes with the collaboration of the government and industries in these respective countries.

# III. Using past experience

EDB did not start negotiations with Japan from scratch. In fact, in the early 70s, EDB had set up joint training centres with Tata of India, Philips of Holland and Rollei (later taken over by Brown Bovery) of Germany. These institutions were geared to produce (then) high tech craftsmen primarily in precision engineering and tool and die making, needed by the new investors. The original formula with these multinationals was train twice as much as you need and share the cost. Over time, EDB progressively assumed the costs, enjoying transfer of the production and training technology of these multinational partners. In the late 70s, a precision optics joint training centre was similarly opened. EDB's craft training centre courses have evolved with technology changes over the years. The Brown Bovery and Tata centres became the campuses of the Precision Engineering Institute in 1987, to pioneer mastercraftsman training.

The Industrial Training Board was formed in 1973 to assume national responsibility for skills training, certification and apprenticeship. By the mid 70s it had established nine vocational institutes and introduced a new apprenticeship system. The Ministry of Education also established a second polytechnic. There was close sharing of experiences among these parallel streams of development.

Besides providing skilled people for industries, the interaction with multinationals helped EDB's staff to learn how to work with firms and to better assess and anticipate their training needs. Among the new ideas debated was the practicability of adopting the German dual system of training for their trainees. At that stage of early industrial development, EDB decided that, for various reasons, Singapore could not adopt it in its pure form, partly due to the lack of skilled masters to supervise the on-the-job training.

**The German dual system**

The essence of the dual system adopted in countries such as Austria, Germany, and Switzerland is a combination of supervised on-the-job training with a one or two day release for theoretical training at the local technical school. Special provisions exist regarding the curriculum, the obligations of the enterprise, the responsibility of the supervisor as well as remuneration. At the end of training, students must pass an exam leading to national certification.

An alternative version of the dual system is the SENAI system in Brazil, in which both theory and practice are provided by the training institution. The difference from conventional technical schools is that the learning environment, the rhythm of work, the profile of the instructors, and the orientation of the curriculum tends to be closer to industry. Even in countries such as Germany and Switzerland such institutionalised versions also exist.

The fact that Singapore decided not to immediately adopt the dual system reflects the proactive, critical approach to technology transfer. Even though it considered it to be an idea worth pursuing, and the technical assistance to do it was available, EDB realised that the majority of the local firms were not ready. Even now, at the time of this write-up, the

VITB is really only beginning to move, it is taking the first steps towards substative improvements to the system to shift it towards the Dual System. But there is still no intention to introduce legislation of any sort.

While an approach based primarily on on-the-job training was ruled out, EDB was also not entirely convinced that the discipline-based approach of the polytechnics was the best solution for its high tech but skill-based needs. These were some of the reasons why a new training approach was chosen for the new technology institutes. They would be more practical, job-oriented, but learning would be imparted in a training institution, not on-the-job. Theoretical and practical training would be provided in-house, but the training should be as close to real-life as possible. The full training cycle would consist of two years of institutional apprenticeship training (journeymen), leading to ITB's National Trade Certificate, Grade 2 (NTC2) followed by 2-3 years of work experience, after which the graduates would gain the higher EDB Craftsman Certificate.

As mentioned before, three new training institutes were created at about the same time. For the purposes of illustrating the process of technology transfer behind the building-up of these institutes we will concentrate our focus on the Japan-Singapore Technical Institute (JSTI) and refer only occasionally to the other two institutes.

### A. The JSTI - the first five years

JSTI was originally created to provide skilled workers (journeyman level) for operation and maintenance jobs supposed to be required by the then modernising Singaporean factories. Training would concentrate on two needs of the then infant industry: tool and dye making.

An agreement was signed with the Government of Japan to provide the technical assistance necessary for the development of a joint-undertaking. The usual steps were taken: Japanese experts were brought in, Singaporean counterparts were hired and trained in Japan and on the job; an appropriate curriculum was designed and updated over time. Directorship was shared between Japanese and Singaporean engineers. A few critical characteristics of these institutional arrangements are worth mentioning.

As it is widely known, the preferred mode of training in Japan is on-the-job - as opposed to institutional training. Most of the high-tech industries also adopt a broader assignment of tasks, thus favouring multi-skilling and broad-based trained workers - as opposed to the highly compartmentalised workers typical of the modern manufacturing firms of the fordist type. In a sense, Japan was thus offering an expertise which in a sense it did not have and did not favour, at least as far as pre-employment training was concerned. Was this a disadvantage or an advantage?

A second characteristic was the profile of the staff. Given its intention to absorb as much industrial technology as possible - and not only the capacity to train skilled workers, the Singaporeans hired counterparts who were able to work as real partners to the Japanese experts. Thus, most of the JSTI staff had engineering degrees in addition to 3-5 years of industrial experience. They were motivated and capable of working with industrial processes, industrial projects and R&D activities - teaching being an important by-product of their activity. Their profile facilitated establishing and maintaining dialogue with industries in Japan and in Singapore.

A third characteristic - to a great extent derived from the first - was the freedom the institution had to organise training around the needs of the workplace. The institute was not part of the education system. Even though its trainees would be eventually certified by the then Industrial Training Board, it enjoyed sufficient freedom to establish its own curricula. Training needs were assessed in the local, Singaporean industries, which were then just starting to adopt computers, CNC, CAD-CAM, robots and automated production facilities. Training

was organised around laboratories and an emulated work environment - given the lack of good role models in the existing factories. The idea behind the laboratories was to integrate knowledge into industry-relevant contents - instead of offering discipline based curricula typical of technical schools and polytechnics.

In fact, the ITB/VITB training methodology has never been discipline-based. ITB/VITB's Curriculum Model must certainly have been a major input into EDB thinking. There was and is a strong cross-fertilisation between the EDB and the ITB/VITB. EDB's staff sits on VITB's content committees and VITB are on EDB centres's management committees and evaluate and certify their courses. Looking retrospectively, it is tempting to suggest that EDB adopted vocational approaches for high tech craft and subsequently technician level training. One of the legacies of such traditions is the fact that since the first day in the institute, even students in the higher level courses have to work in workshops and involve themselves in practical activities.

The work environment also reproduced part of the Singaporean and part of the Japanese work culture. Students remained at the institute 48 hours per week, 44 weeks per year. This can be compared with the 44-hour/week in industry and 26-30-hours/week during two academic semesters per year in the conventional polytechnics.

A few other characteristics of the Japanese-style slowly emerged, such as the idea of total immersion in the work. Another was managerial style, which is part of the Japanese work ethos, and is hard to define: consultation, consensus, work habits, the obsession with quality, and other work-related habits. According to observers of the local scene, such style is still characteristic of the JSTI, even today when the Japanese experts have virtually left. According to these same sources, the JSTI's management style is clearly different from the other two institutes (the French and the German ones) in some of these aspects. Part of this is also due to acculturation through training and the frequent interactions of the staff with Japanese industries in Japan and in Singapore.

Five years after it started, the programme underwent a dramatic change: both the Japanese and the Singaporeans realised that skilled workers in the conventional sense of skill was not what they needed. The needs of high tech industries in Singapore - as in Japan, for that matter - called for skills of a higher order - a mix of practical and technical knowledge. Moreover, for the institute to respond to its mandate, it had to move up into technical level training. The entire approach had to be changed. Training should still keep its work-orientation, but it should provide students with a sounder, more broad technical basis to deal with the complexities of high tech in the workplace. In other words, more technical education, and less skills training. This is why a new type of training was needed, and the Singaporeans decided to continue seeking help from the Japanese.

Even more than before, the Singaporeans did not merely intend to learn from the Japanese how to upgrade the level of their workers, or how to set up a training institute: That they already knew how to do through the experience acquired in the three institutes, as well as through their own national polytechnics. What they wanted was to further their contacts with Japanese industries and be closer to sources of Japanese technology. And they knew only too well that the Japanese government and their industries might also have their own reasons to strengthen relationships with Singapore. It was under these implicit expectations that a new, 5-project was negotiated.

### B. The second phase

Much ground was already covered during the first phase, as far as conventional institution building processes are concerned. Less conventional, perhaps, was the direct access of the Singaporean staff to Japanese industries in Japan and Singapore. This provided a vital link to keep the institute's staff abreast of technological changes and of the present and future

needs of industry. The prevailing idea was that Singapore tomorrow is Japan today.

The explicit reason for extending the co-operation with Japan was to introduce higher-level, technician training for high tech industries. As the apprentice programme was discarded, two new courses leading to Industrial Technician Certificates were introduced - one on industrial electronics and the other on mechatronics. We concentrate our discussion on the mechatronics course, since it throws some light on the heart of the technology being transferred and on the process of transfer of new ideas and concepts - including that of the mechatronics.

The term mechatronics was introduced by the Japanese in the late seventies, when the country was moving away from the concept of specialised and multi-skilled workers into the idea of flexible, all-round workers (for a discussion see Ministry of Labour, Japan, 1988):

> Quote from the Proposals by the Enterprise-Based Training Research Committee of the Vocational Training Bureau of the Ministry of Labour of Japan published under the title: Human Resource Development in the Mechatronics Age.
>
> The skilled worker envisaged was neither a single-skilled nor a multiskilled worker capable of operating two or more machines or doing a compound job, but an all-round skilled worker with academic aptitude and technical knowledge. Single-skilled and multiskilled workers might be developed by on-the-job training. But it would be hard to develop all-round skilled workers with practical skills and theoretical knowledge through on-the-job training alone. .. (Op. cit. p.23)
>
> ... In the Mechatronics Age the importance of technicians who develop, install and maintain mechatronics machines and production equipment will increase...basic finishing skills, basic machining skills, basic electric and electronic theories and microcomputers should be made common subjects (p.27).

As a consequence, mechatronics technicians are necessary to take care of mechatronics products. It is easier to exemplify than to define what a mechatronics product is: while a teleprinter has 5,000 parts, a modern-version VCR has much fewer parts, integrated around a PLC - a typical mechatronics product. It takes more than the juxtaposition of electronics, electric and mechanical parts: mechatronics is an integrated concept, a way of thinking and integrating or fusing the contributions from all these separated fields.

**Fault-finding in mechatronics devices**

Disk-Drive Corporation is one of the world's leaders in the production of disk-drives. The production of disk-drives is a rather complex operation. Each new disk drive presents unique, new problems. The more the circuits become integrated, the harder it become to identify errors and their causes. The firms which survive and thrive in the competition are the ones which are able to efficiently produce new models of disk-drives with the minimum number of defects and in a short time.

Detecting and fixing errors thus becomes a major challenge. Mechatronics are trained to understand the integrated logic of mechatronics devices. However, their competence can only improve through experience with different drives. This creates a major challenge for firms: to survive and prosper, they need to learn very fast. To learn, they need to change products very often. To change products very often, they need a highly trained, competent workforce.

Moreover, there are also mechatronics production tools, such as robots and a plethora of other information- age production devices typical of flexible manufacturing systems.

In Japanese industries, since the late seventies, and even in Singapore, by 1986-87, there were certainly markets for the mechatronics: even before the word was introduced, or before trained technicians were available from schools, employers already preferred to hire technicians with the ability to simultaneously understand, operate, diagnose, troubleshoot and maintain such machines.

How employers and training organisations dealt with the training of such integrators is another matter. In the case of Singapore, many alternative institutional and training responses were put in place, and they still co-exist. Comparing these responses with the response given by the JSTI may help us to better understand the conceptual influence transmitted through the collaboration with Japan.

Singaporean firms have been dealing with the problem of the multi-skilled worker in a number of ways: they hire mechatronics technicians, if they can; they train their mechanic technicians in electronics, or vice-versa; they keep specialised technicians performing separate functions; they integrate production and maintenance functions, depending on the availability of multi-skilled, integrator technicians. In a same industry one can find mechatronics technicians working side by side with mechanic or electronic technicians, and doing what are formally the same tasks. In short, at this early stage of high tech production technologies, firms have been coping with their operational and maintenance problems in a number of different ways. There is still no prevalent pattern or no evidence than one way is clearly more effective than the other. One reason might be that broadly-based technicians make up for the missing training themselves- and find idiosyncratic ways of integrating the various pieces of knowledge.

Training institutions in Singapore tackled this same problem in a number of ways. In one polytechnic, the mechatronics curriculum, offered by the department of electronics, is made up of 70 per cent of electronics and 30 per cent of mechanics courses: the mechatronics technician is essentially an electronic specialist. In another polytechnic, the mechatronics course is a joint departmental offering: the curriculum is roughly 50 per cent electronics and 50 per cent mechatronics. In both cases, curricula are essentially discipline based - the real integration only occurs at the practical project level.

Another approach was adopted in the third training institution. There, the mechatronics curriculum is offered by a new department, which grew out of electro-mechanics. The curriculum is balanced in another way, roughly 30 per cent electricity, 30 per cent electronics and 30 per cent mechanics. The curriculum is still discipline based, but the goal is to provide some level of integration within each discipline. Professors are explicitly asked to provide such integration, and they are all trained in areas other than that of their original specialisation to ensure their capacity of working beyond strict disciplinary boundaries.

The mechatronics curriculum at JSTI - which proceeded and to a certain extent inspired all these other efforts - has distinctive features and to a great extent reflects the Japanese connection:

> Our mission is to train a new breed of mechatronics technicians to set-up, operate, maintain and trouble-shoot highly sophisticated equipment and machinery in modern automated factories with a high degree of integration among electronics, computer and mechanical technologies JSTI Information Brochure, 1991.

A mere inspection of the curriculum offerings would not reveal the actual level of integration: the disciplines offered are essentially the same ones taught in the other institutions: automation and controls; industrial automation design; pneumatics; hydraulics; robotics; CNC; mechatronics maintenance, computer programming.

The way the curriculum is conceived and taught, however, reflects the distinctive characteristics of the institution and the influence received from Japan during the development phases.

First, the curriculum is not discipline based: the whole institute is organised around laboratories which are closer to an R&D or a firm laboratory than to academic departments. The staff allocated to laboratories deal with concrete issues - robotics, flexible manufacturing systems, etc. - not with discrete disciplines.

Second, students participate in the actual work of the integrated labs specialised in Robotics, FMS or MicroCADD since the first day they enter the institute. The work ethic instilled during the first phase of the project was maintained, even though the nature of the work changed. Before, it was skill training: now, it is project work - just like in the real life of high tech industries. For example, in these modern-age workshops students work on projects utilising sequential controllers, microprocessors or computers to generate programmes for control systems in automatic machines or assembly lines.

Third, the curriculum, particularly in the second year, is organised around integrated issues and not typical subject matter disciplines. During the last six months, students are engaged on a real R&D project contracted out to local firms and supervised by one of the teachers, who is responsible for delivery and quality.

During this six month period students take turns as project leaders: this is an opportunity to learn supervisory and other practical skills such as scheduling, planning, working with groups, communicating, taking decisions on costs, quality and all other project-related matters. These projects are originated and sponsored by local industries, and are jointly supervised by representatives of industries as well as by the responsible teacher.

The pedagogic intention of the project reflects the core of the Institute's philosophy. First, the project replaces actual internship in industry, because the Institute believes that it can represent a superior learning opportunity when compared to the typical internship programme. Second, the project is an important moment for integrating the knowledge and skills characteristic of mechatronics. Third, the project is an

opportunity to complement - without loading - the explicit curriculum with other skills considered basic for the non-technical roles of the future technician.

## C. Some thoughts about the second phase

Before we conclude this discussion, a few comments are in order.

First, it is very hard to assess the actual degree of integration of the curriculum, and how much it actually reflects mechatronics thinking. The idea of mechatronics is as Japanese - or rather, oriental - as the concept of harmony (Hu-), which bears similar meanings with the ideas of zen and tao. Behind all these philosophical words lies the notion of integration and harmony - which some technical educators in the JSTI identify in the process of understanding and teaching mechatronics. For them, mechatronics is not a balanced curriculum, but it is Hu-, it is fusion, it is a way of looking at integrated technology. Whether or not this is reality, whether or not students understand and integrate the approach in their heads, whether or not they think mechatronically is not possible to evaluate.

What is possible to observe, however, is that a process of cultural transmission clearly took place. The fact that the Japanese had no direct experience with formal, pre-employment, institution-based technical training of mechatronics as not an impediment to successful technology transfer. The way the Institute was originally set up and later adapted for the new curriculum favoured a project, integrated approach, rather than the discipline-based tradition of polytechnic institutions. What JSTI learned to do was to translate the realities of the Japanese high-tech shop-floor into a workable and meaningful learning experience.

At the same time, it is also important to observe that due to this same lack of disciplinary rigidity, but feeling the need for broader-based technical training, it was possible to incorporate conventional wisdom into the curriculum. In its present form, the first year of the curriculum - taken at face value - is not very different from the ones taught at other polytechnics: mathematics, engineering drawing; mechanics of material; electronics; electrical technology; electrical measurement; computer programming. The way it is taught is another matter. The presence of basic disciplines in the curriculum is in part due to the need to upgrade the basic scientific and technological knowledge of the workers of the future- as was mentioned in the report quoted earlier. In part it is a reflection of the inevitable convergence of education and training: the more training is advanced, the closer it resembles education. This seems to be true even in a training institute conceived by shop-floor engineers with no tradition of pre-employment or discipline-based training.

# IV. Results and perspectives

Over the years, JSTI - like the two other EDB institutes - have been evolving along with similar directions. We will briefly examine what is happening to the students, the curriculum, the faculty, the institute-industry integration, the Japanese connection, and to EDB.

## A. Students

Most of the students from JSTI receive scholarships, in exchange for which they are bonded for three years after graduation. This bonding responds to EDB's strategy of guaranteeing the supply of skilled manpower to the industries attracted to Singapore. Graduates from JSTI are primarily deployed to respond to the needs of industries thus attracted, and which utilise high-tech production technologies. Even though the primary intention is not to provide manpower for Japanese firms, over 50 per cent of the graduates end up in these firms. The same is true of the French and the German Institutes.

According to tracer studies conducted by JSTI, the graduates, who receive the Industrial Technician Certificate after the two-year course, tend to receive salaries comparable with those of the graduates of the other institutes - which offer a three-year, higher-level diploma.

## B. Curriculum

Two major curriculum changes occurred in JSTI's history, and they reflect changes in the perception of the needs and demands of the local industries. The first change was moving away from training apprentices in precision engineering, tool and die-making skills and offering a higher order certificate in applied technology skills, characteristic of the present programmme. The second change is now being prepared, when the Institute is moving into design, product innovation and R&D activities. This move reflects the fact that local Polytechnics already offer mechatronics courses. But mostly it reflects the Institute's mandate to innovate and to prepare manpower for Singapore's next stage of technological development, following inspiration from Japan. The existing contacts with industries in Japan and their subsidiaries in Singapore should guarantee an update flow of information to keep the organisation abreast of new developments in its areas of competence.

## C. Faculty

As described earlier, the faculty of the JSTI is composed of engineers and technicians. Their major task is to achieve the mission of the Institute - i.e., to open up windows to incorporate and disseminate the various types and levels of industrial applications of electronic-based technologies. Most of the faculty has been trained in Japan - or have been closely associated with Japanese counterparts. It is part of their current job to identify and tackle technological challenges arising from local industries - either by mastering the latest advances in their field or by helping local industries to solve critical problems. By keeping up-to-date in their respective fields, the faculty is also able to transfer to their students the skills they need to quickly adapt to the present and future demands of the local industry.

## D. Institute-Industry Integration

More than just being a training institute, JSTI is a strategic arm of the Economic Development Board. Training is one of its activities - but its ultimate goal is to help promote and sustain

the technological development of Singapore. As part of this strategy, EDB has located some of its high tech laboratories within JSTI, such as the Robotics and Factory Automation Laboratory, the Flexible Manufacturing Systems Laboratory and the MicroCADD Lab. Besides doing R&D work, these laboratories also collaborate directly with industries in both research and training activities for employees.

One of the legacies of the Japanese was to conceive each training activity at various levels. Since Japanese firms tend to have three major hierarchical levels - management, technical and operational - any course which is deemed important to improve efficiency or quality is conceived and delivered at three levels of complexity. The ultimate objective of this approach is to develop a common vocabulary and a common understanding of the issues being tackled by the organisation, so that all workers - at their respective level - can contribute to further improve the performance of the organisation. Knowledge is not the privilege of managers, or technicians.

An innovative programmme on Surface Mounting Technology, for example, is being jointly sponsored with Matsushita, and is offered in three calibrated versions to engineers, technicians, and skilled workers.

Surface Mount Technology (SMT) is becoming the dominant general purpose assembly method for printed circuit board assembly and processing. Surface Mount Devices (SMD) are rapidly replacing components inserted with leads so that circuit boards can be made smaller.

Windowing is a frequent word referred to at JSTI. It is probably the Institute's way of responding to its mandate to serve as a platform for technological transfer. Having been able to set up a reputation at home and with their Japanese counterparts, the Institute also became a show-case for Japanese products and technologies. At JSTI- as is the case with the other EDB institutes - Japanese firms donate and locate their latest technology. There, subsidiaries of Japanese firms as well as other Singaporean firms can become familiar with modern manufacturing equipment, obtain services, and hire trained manpower to operate them.

JSTI was structured in such a way that it can open up to the outside world in a number of ways: by housing laboratories or by running them in association with local firms; by developing R&D activities and incorporating them in the training programme; by serving as a clearinghouse to national firms on the latest technological developments; by serving as a showcase for foreign firms to display their newest products while ensuring local back-up through services, technical assistance and skilled workers.

At the institutional level, EDB itself represents one of the governmental windows to deal with technological changes and associated uncertainties. JSTI co-exists and collaborates with other polytechnics and other training institutions - while maintaining its separate identity and strategies.

To benefit even further from the experience of dealing with foreign countries, foreign firms and foreign technical assistance, EDB put in place a system of rotating managers: staff from the EDB spend some time as managers of the three institutes, to foster cross-fertilisation and

## E. EDB

In 1980 Japan already emerged as a mature, developed country, the world's leader on automated production. Singapore was merely a candidate to become a respectable N.I.C. (newly industrialised country). It was probably by defining technical co-operation as a window for mutually beneficial relationships that EDB managed to transform a situation of asymmetry into one of partnership.

collaboration among the institutions and between them and the EDB.

Bamboo is a much loved symbol in the East. It is synonymous with flexibility. The world of high tech requires not only a flexible, all-round worker, but the institutional ability to adapt and to change. This seems to be the key to success in the high tech world. Bambooing might become the most effective strategy for adapting training organisations to the changing needs of high tech industries.

The association between Japan and Singapore had many chances of going astray. Japan was much more powerful and developed than Singapore; there was no guarantee that economic development in Singapore would take the high-tech turn it took; languages were different - they had to communicate in English - a foreign language for both; the initial traditional precision engineering approach had to be abandoned; Singapore wanted the latest technology and access to the latest equipment and industrial developments. Even though Singapore could represent a reliable, complementary partner to Japan, it could also become - or be perceived - as a potential competitor, particularly for U.S. markets. The partnership described in this case illustrates a process of mutual adaptation in which potentially asymmetric relationships were converted into a joint, collaborative process of technology transfer.